

**THE DESIGN AND CONTRUCTION OF ELECTRIC MOTOR CYCLE WITH 250 W 24 V  
DC MOTOR CONTROLLED BY DC CHOPPER**



**This report is composed as one of requirements to complete the bachelor degree (S1) at  
Department of Electrical Engineering, Faculty of Engineering**

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**2017**

**APPROVAL PAGE**

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**SCIENTIFIC PUBLICATION**

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In this study, the writer testifies that there is no plagiarism of opinion and work that have been published by another researcher before, except mentioned in the bibliography, review of literature and those referenced in script writing. Therefore, if it is proved that there are many mistakes in this statement, writer will be fully responsible.

Surakarta, 03 Agust 2017

Writer



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# THE THE DESIGN AND CONTRUCTION OF ELECTRIC MOTOR CYCLE WITH 250 W 24 V DC MOTOR CONTROLLED BY DC CHOPPER

## Abstrak

Pesatnya perkembangan teknologi setiap hari berdampak pada lingkungan, terutama manusia. Teknologi ini dirancang untuk memudahkan dan memberikan kenyamanan bagi manusia. Hal inilah yang membuat para ilmuwan semakin dipicu untuk mengembangkan teknologi yang semakin modern, satu di bidang transportasi. Transportasi yang menggunakan energi terbarukan dan menggunakan sumber daya alam terbarukan, salah satunya adalah motor listrik. Motor listrik ini dikenal sebagai salah satu teknologi ramah lingkungan dan menggunakan listrik sebagai motor penggeraknya. Motor listrik terdiri dari motor listrik sebagai komponen utama propulsi, maka baterai sebagai sumber penggerakannya, semuanya tidak lengkap jika tidak menggunakan pengontrol kecepatan putar motor listrik agar sesuai dengan kebutuhan pengguna motor listrik. Motor listrik yang digunakan adalah brushed dc yang memiliki banyak kelebihan, terutama pada kecepatan pengendali. Pengontrol yang digunakan dalam bentuk DC chopper. DC chopper adalah coverter dari tegangan DC murni menjadi tegangan Dc variabel sehingga dapat menyesuaikan tegangan pada motor DC.

**Kata kunci:** Kontroller, DC Chopper, Motor DC, Sepeda Motor Listrik, Trasportasi

## Abstract

The rapid development of technology everyday has an impact on the environment, especially human. Technology is designed to facilitate and provide comfort to humans. This which makes the scientists increasingly triggered to develop increasingly modern technologies, one of them is transportation. Transportation that uses renewable energies and renewable natural resources is the electric motor cycle. This electric motor cycle is known as one of the eco-friendly technologies and uses electricity as its driving force. The electric motor consists of an electric motor as the main component of the propulsion, and the battery as the driving source. All of it is incomplete if not using a rotary speed controller of the electric motor to fit the needs of the electric motorcycle users. Electric motor are used brushed DC motor which has many advantages, especially in the controlling speed. The controller used in the form of DC chopper. DC chopper is a coverter of pure DC voltage into variable DC voltage so it can adjust the voltage on dc motor.

**Keywords:** Controller, DC Chopper, DC Motor, Electric Motor Cycle, Transportation.

## 1. INTRODUCTION

The increasing of the earth's age certainly equals with technology development. It will facilitate human and keep to expanse. Technology will be always repaired until it reaches perfection for comfort and its usefulness for humans.

Transportation is one of technologies which develops rapidly. In the past, human only walked, but now human can go far away by using the energy of an engine. The engine can move because it

uses the fuel which the fuel is made of the rest of life from fossil. The fuel is a material which spurs motor to move because it is capable of changing energy, especially heat energy in the process of combustion.

Observed from moving material, transportation uses fuel certainly it has disadvantages. One of them is it is natural resources that cannot be renewed in other words it can be discharged if we use continuously. The other disadvantage is the rest of the process of combustion which occurred in the motor's movement to be one of the factors of causing global warming. Of course, it leads to new problem to our earth and has impact for all ecosystems.

This new problem makes researchers to develop a new technology namedly renewable energy. The nation's future was not to be out done in the manufacture of energy-efficient vehicles, they competed with each other to develop energy-efficient vehicles that we usually refer to as an electric motor cycle.

The electric motor cycle is an eco-friendly technology of transportation which is designed to reduce emissions from vehicle fuels and can be used for recreation, fitness and more. (Aris Budiman, 2012). The tool is driven by a DC motor to convert electrical energy into kinetic energy. DC Motor is one of a kind electric motor which has profit easily to control, low price and easily obtained. It is considered as a SISO (Single Input and Single Output) system which has torque/ speed characteristic and compatible with most mechanical loads (Nazani A., 2013). Motor itself requires controls to get the output desired results as the drive components electric motors cycle. DC motor must have speed control in order to stabilize the output speed of the motor within their needs. Controller will put vary whenever there is a difference in the reference speed and the speed feedback. (Jaafer Sadiq Jaafer, 2013)

For this final project, it will make a control the speed by using a DC Chopper which it is as unidirectional constant input voltage converter. Output voltage can be varied by changes in duty cycle control circuit. Chopper system offer smooth control, high frequency, faster response and regeneration facility (Varun R.V, 2015).

In the DC Chopper, it uses IC TL494 as the center of circuit. TL494 device has design primarily for power supply control. This device offers the flexibility to tailor the power supply control circuitry to a specific application (Texas instruments, 2015).



## **2. METODE**

The method which are used in this experiment as follow

### **2.1 Literature**

The author begins this research by collecting journals from various sources and seeking the expertise of some experts as a reference in making this research.

### **2.2 History**

Make people who have experience as a reference in consultation on research, and make the motivation because success will be the work equivalent to this research.

### **2.3 Experiment**

Doing various experiments to accomplish this research. Passing through the stage of making and trial and error that many occur which aim to further complete results from this research.

### **2.4 Collecting data**

Search the data from the experiment to find out the weaknesses and advantages of this experiment tools, and can monitor the development of this tool.

The research is started from searching of DC motor which corresponds to electric motor cycle and it is obtained motor dc with the specifications 250 W, 24 V, 14 A, 2750 RPM and it is brushed DC motor so motor moves maximally to 24 V and the number of burden is 14 A

By the electric motor, the further research is to make controller speed; that is DC chopper. To make this DC chopper, it takes about 5 months. In the first month, the writer studies about DC chopper and finds the appropriate circuit to the motor DC. In the second month, starting to make DC chopper with already available equipment. In last three months, doing trial and error, trying controllers directly on electric motor gradually from low source to high source and from electric motor without loads to motor with loads. At trial error process, there are a lot of new components to adjust the strength of motor in DC chopper. After it finish, DC chopper is getting perfect, the writer does experiment and collecting data. As motors motorcycle itself, the use of dry accu ( battery ) of the car will be chosen because it is the most optimal source which looked from the current paid by a car battery.

After all is done, DC Chopper has been fairly done test and retrieved data. As the driving force of the motor itself, the use of battery from the car is the most optimal choice because the current output from the car battery is more durable than using the motor battery in accordance with the specification of the electric motor itself in consuming current and the voltage is large enough. The finishing of DC

chopper continued with the assembly of electric motor bike to complete this final task and search for the last data.

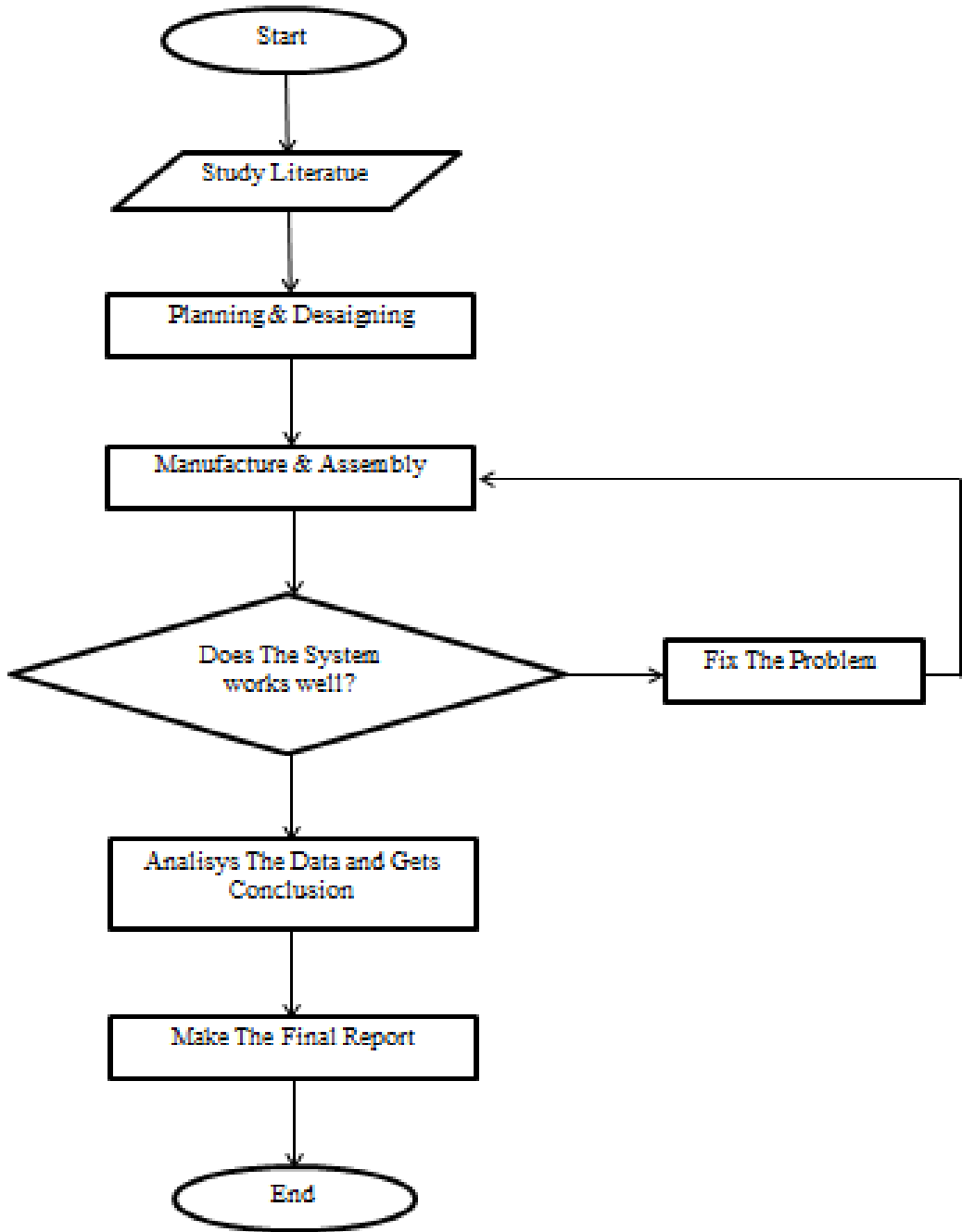


Figure 1. Flowchart



## 2.5 Motor DC

An electric motor that used for run motor cycle is a motor DC. DC motor is divided into two types. They are the brushed DC motor and brushless DC motor. Both of them have similarity on the quiet stator and rotating rotor. The significant difference of them is on rotor. Brushed DC motor has electric and magnetic rotor and its stator has the natural magnetism. It is contrary to the brushless DC rotor and stator.

The writer uses brushed DC motor for this research. Motor is running because it occurs different potential in two terminals which will flow the current from the positive pole to the negative pole. Two additional to drain. The current flow will pass brush and lead to winding motor which is in a magnetic fixed field and produces the rotation on motor. The greater current and potential difference in motor, the quicker pace of motor's lap



Figure 2. Name Plate Motor DC

Based on name plate stamped on brushed DC motor, this motor has specification as follows: model motor of this DC is MY1025, maximum input voltage is 24V and rated maximum current 14 A. It also has the speed of turn maximum 2750 RPM and an output voltage maximum 250 V and torque of 85 kg.cm- 100 kg.cm. Electric Motor with built in gear at the end of this shaft dimension in diameter 10cm x thick 8 cm, for dimensions shafts; its long 2.5cm x diameter 12 mm, and its weight is 2 kg.mm.

## 2.6 DC Chopper

An electric motor requires a controller to control the speed swivel from the electric motor. A controller which is used is DC chopper. DC is a static power electronic device which converts fixed DC voltage input to a variable output voltage DC. (Varun Rohit Vadapalli, 2015). The output of DC chopper is DC that can be arranged its current. DC chopper components consist of IC PWM which PWM is controller of chopper itself. Mosfet is for managing big or small the voltage, as well as potensio as reference to do the size of a voltage needed.

Chopper is divided into 3 types based on its function as follows

- a. Chopper step down : This chopper is a chopper that works to lower the voltage.
- b. Chopper step up : This step up chopper has a function as a voltage boost .
- c. Chopper step up-down: This chopper is dedicated to adjust the output in a Dc motor, voltage can be increased or even lowered as needed.

This DC chopper has a working principle starting from the incoming voltage on the motor is 24 V while in the DC chopper circuit voltage first entered on the component 7812 which will make the voltage drop to 12 V and given resistance in the form of resistors and capasistor to store the voltage so that the voltage is more stable , After the stable voltage is divided into two IC the source of the BD transistor and the source of TL494 (IC PWM).

### 2.6.1 IC TL494

The PWM technique involves generation of a digital waveform, for which the duty cycle is modulated such that the average voltage of the waveform corresponds to a sine wave( Ian F. Crowley,2011).

In this circuit, PWM is used in the form of IC which serves as the center of DC chopper, IC PWM used is TL494. The TL494 is a fixed frequency, Pulse Width Modulation (PWM) control circuit designed primarily for switch mode power supply control (datasheet TL494). IC TL494 has a configuration on its legs, can be seen in the following picture:

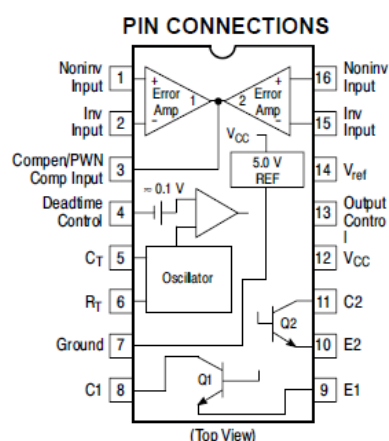


Figure 3. Pin Connections TL494

Note :

Pin 1. Non inverting input to error amplifier 1

Pin 2. Inverting input to error amplifier 1

- Pin 3. Compenen input componen PWM for feedback
  - Pin 4. Dead time control comparataor input
  - Pin 5. Capacitor terminal used to set oscillator frequency
  - Pin 6. Resistor terminal used to set oscillator frequency
  - Pin 7. Ground
  - Pin 8. Collector terminal of BJT output 1
  - Pin 9. Emitter terminal of BJT output 1
  - Pin 10. Emitter terminal of BJT output 2
  - Pin 11. Collector terminal of BJT output 2
  - Pin 12. Positive supply
  - Pin 13. Select single-ended/ parrallel output or push- pull operation
  - Pin 14. 5-V reference regulator output
  - Pin 15. Inverting input to error amplufier 2
  - Pin 16. Non inverting input to error amplifier 2
- (texas instrumental,1983)

This IC is make the PWM output wave, and can controlled as needed. The advantages the IC is the output voltage until 42 V and stay on until 70°C, so it will be enough to be central of DC chopper.

## 2.6.2 Mosfet IRF 3205

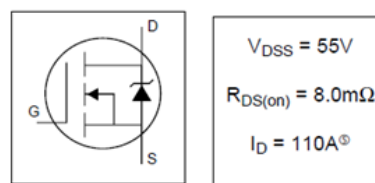


Figure 4. Data of IRF3205

Mosfet IRF 3205 is mosfet with type n- channel on controlling . It has work principle when voltage into drain (D) , must pass through the gate (G) who have a diode in line .In addition , the voltage on gate must bigger than voltage on drain, so gate can open and voltage will going to source (S). But when voltage entrance of source, because voltage can be directly to drain without ever having

voltage bigger than gate. This is because in line at a diode gate to drain. From the Figure 4, the mosfet can operation until voltage 55V and current 110A.

Mosfet is also serves as the tension and lowering to streng then current through an mosfet . In additio, mosfet it can improve on duty cycle PWM in 2% , this is evident from the waves obtained for the series. The result can look on figure 5 and 6, the mosfet can lost the riak from the wave.



Figure 5. The Wave Without Mosfet

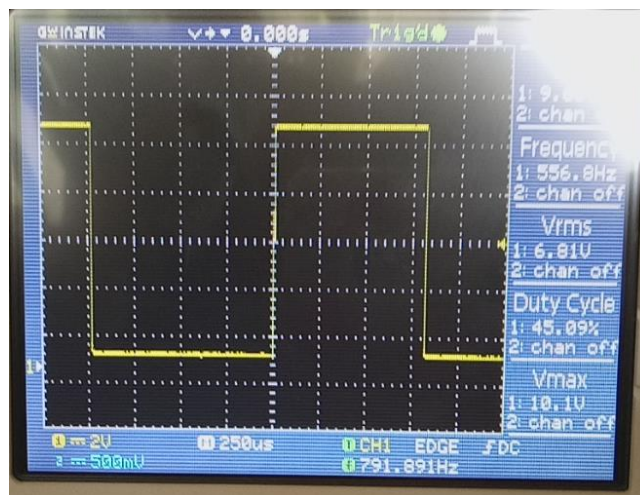


Figure 6. Wave With Mofset

### 3. RESULT AND DISCUSSION

The result of experiment gets some discussion, there are:

#### 3.1 Circuit of Chopper

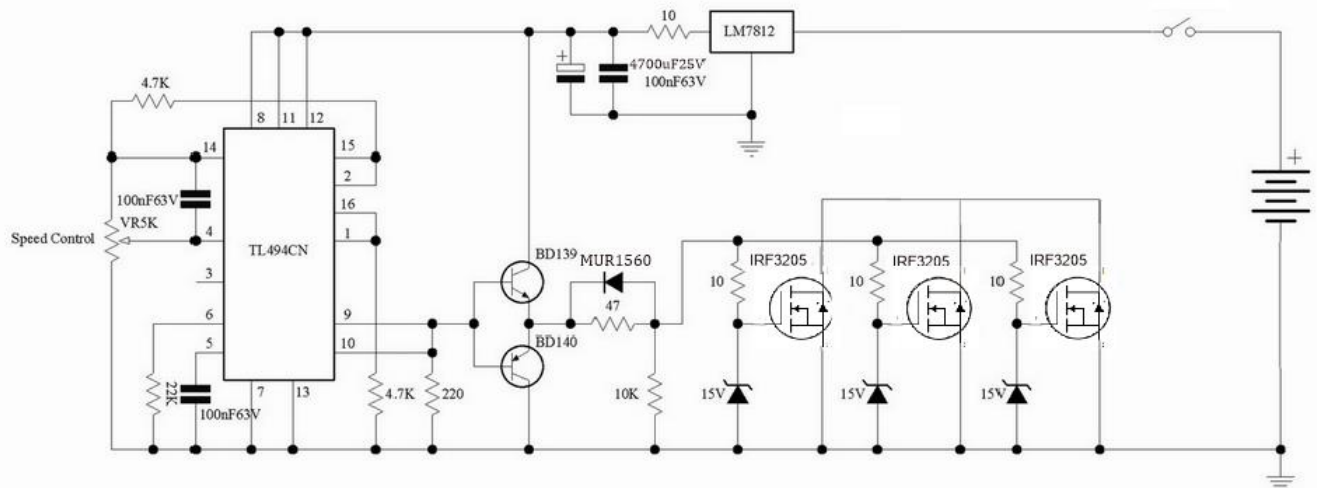


Figure 7. DC Chopper Circuit

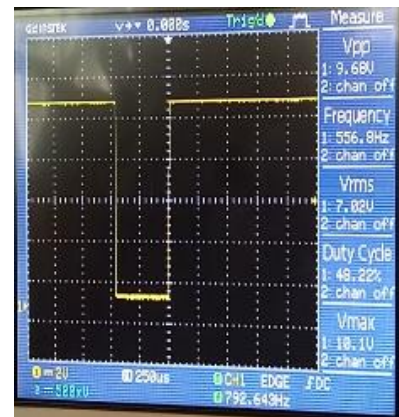
From the figure 7, the circuit use TL494 as IC PWM to be the center of the DC Chopper. For the strengt the circuit use Mosfet IRF3205 on paralle circuit. The important of DC Chopper is Diode, to lost the riak from the voltage, because from the real DC voltage to be variable DC voltage, voltage not will perfect without diode. In addition diode have fuction as rectifier current. The kinds of diode are MUR 1560 and Dioda Zener. LM7812 is used to stable voltage and get the output 12V for the circuit. BD 139 and BD 140 is the couple transistor NPN and PNP to be switch.

Process on the circuit: starting from the all connection with the source, the voltage will input to the LM7812 to stable the voltage and voltage gets regulation until 12V. Resistor will help to product the voltage and capacitor will save voltage temporarily. After that, voltage will divide to transistor and input to the IC TL494. On the transistor, voltage will save until base gets voltage to open the emitior. The diode MUR 1560 is the ultrafast recovery diode, has same spesification with general diode but speed to rectifier faster than general diode. So, in here the MUR just for gets the faster rectifier. The voltage will go to gate the mosfet, opening the gate and going to drain. The voltage from the ground to gate of mosfet have diode zener, it to cut the voltage if the voltage more than the breakdown voltage from diode zener.

### 3.2 Result Of DC Chopper



(a)



(b)

Figure 8. a and b is Wave's Result of Chopper

The center of DC Chopper is PWM, so the wave result is same with PWM. Then, Chopper will control variant of Duty cycle to control the electric motor. From the figure 8, show the varian of duty cycle. It has many parts as follow  $T_{on}$  (Time Pulse "High"),  $T_{off}$  (Time to Pulse "Low") and  $T_{tot}$  (Total Time on a Pulse). From the result gets some conclusion, when  $T_{on}$  full the rotary speed and voltage will be higher, and the speed motor will faster than the starting. But, when  $T_{off}$  full so the motor on variant 0 and motor stop.

Table 1. DC Chopper without Loads

Potensio	Voltage (V)	Current (A)
0%	0	0
25%	6	1.50
50%	12	0.72
75%	18	0.56
100%	24	0.43

From the table 1, the result control chopper againts voltage and the speed as follows:

- The condition on netral the motor did not get voltage and current, so the motor stop.
- The higher current is 1.50 A when the voltage still on 6 V, and motor still starting, did not move, and has noise from motor.
- The Voltage 12 V and current 0.72 A the motor move but still slowly.

- d. The motor has standart speed when 18 V and 0.56 A.
- e. The higher voltage is 24 V, that is the maximal voltage and the current only 0.43 A.

Table 2. DC Chopper with Loads

Potensio	Voltage (V)	Current (A)
0%	0	0
12%	3.6	9.4
25%	6	9.2
50%	12	9.15
75%	18	9
100%	24	8.9

From the table 2. The DC Chopper with loads will get different result, as follows:

- a. The higher current is 9.4 A when the Voltage just 3.6 V, and the motor did not move and more noise than the motor without load.
- b. The first motor move, when the current 9.2 A and Voltage is 6 V, motor move still slowly and still have noise.
- c. The motor move and has not noise on 6 V and 9.2 A, move motor faster than the b, but still slowly.
- d. The motor has standart speed when the voltage 18 V and 9 A.
- e. The motor has faster move om maximal voltage or 24 V and 8.9 A.

From result table 1 and 2 get some informations, there are:

- a. When the voltage in minimum then current will in maximum condition, so instead when the current in minimum condition so the voltage will in maximum condition.
- b. The load did not influence the voltage, but influence the current.
- c. A decrease in current unstable, but in voltage stable.
- d. Noise is first respont motor before move, and motor will be more noise because loads.

### 3.3 The Failure of PCB Chopper

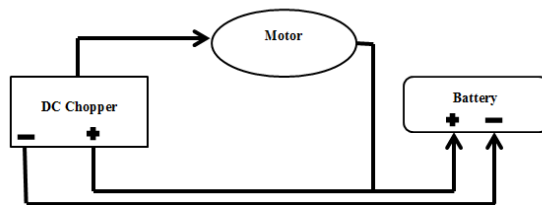
In process make the DC Chopper has many problem and failure. That are because many factor, as follows:

- a. The kind of PCB, the high current make the temperatur of PCB will be hot and if using the general PCB, that will be broken PCB and circuit line. Minimal use Fiber PCB or the best PCB.



- b. Size of Circuit line, because the high current need big line to flow the current. If try use the small line, the line will be broken.
- c. The kind of Mosfet and IC. Every IC and Mosfet have different function and work principle, so must know where needed IC and Mosfet on your circuit.
- d. The variant of Diodes. Diodes have many variant and every variant different work principle, choose the diode needed, so the circuit will safety.
- e. Cooling, the high temperatur make component be hot and if the component can not survive with temperatur, they will be broken. The cooling will minimize high temperature dan save the component.

### 3.4 The Circuit on Electric Motor Cycle



(a)



(b)

Figure 9. a and b Scheme Connection on Eletric Motor

From the figure 9, The Battery is 24 V and 30 Ah to supplly motor and DC Chopper to work. The battery in series circuit from 2 batteries, because a battery just have 12 V. Motor needed battery to make trun on motor, so it can be controll. The DC chopper using battery as source to process the voltage will control the electric motor. The result voltage from DC Chopper, will control the electric motor, that is make output must connect with DC motor.

### 4. CONCLUSION

From many experiment gets more conclusion, as follows:

- 1) The Current and Voltage have opposite condition, When the voltage in minimum then current will in maximum condition, so instead when the current in minimum condition so the voltage will in maximum condition.

- 2) The high current influence from Loads on motor.
- 3) DC Chopper consisting of IC PWM, Mosfet, Diode, Transistor, Capacitor and Resistor.
- 4) To make DC Chopper with Higher Current need to pay attention to some points, that are:
  - a. The size of circuit line
  - b. The kind of PCB
  - c. The kind of IC and Mosfet
  - d. The Variant of Diode
  - e. Cooling

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